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**UTILITY PATENT APPLICATION TRANSMITTAL**  
**(Large Entity)**

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Docket No.  
13613

Total Pages in this Submission

**TO THE ASSISTANT COMMISSIONER FOR PATENTS**Box Patent Application  
Washington, D.C. 20231

Transmitted herewith for filing under 35 U.S.C. 111(a) and 37 C.F.R. 1.53(b) is a new utility patent application for invention entitled:

**VIDEO CODING BY ADAPTIVELY CONTROLLING THE INTERVAL BETWEEN SUCCESSIVE  
PREDICTIVE-CODED FRAMES ACCORDING TO THE MAGNITUDE OF MOTION**

and invented by:

Yutaka Yokoyama  
Yasushi Ooi**a CONTINUATION APPLICATION**, check appropriate box and supply the requisite information:**Continuation** ☐ **Divisional** ☐ **Continuation-in-part (CIP)** of prior application No.: \_\_\_\_\_

Which is a:

**Continuation** ☐ **Divisional** ☐ **Continuation-in-part (CIP)** of prior application No.: \_\_\_\_\_

Which is a:

**Continuation** ☐ **Divisional** ☐ **Continuation-in-part (CIP)** of prior application No.: \_\_\_\_\_

Enclosed are:

**Application Elements**

1. ☒ Filing fee as calculated and transmitted as described below
2. ☒ Specification having 25 pages and including the following:
  - a. ☒ Descriptive Title of the Invention
  - b. ☐ Cross References to Related Applications (if applicable)
  - c. ☐ Statement Regarding Federally-sponsored Research/Development (if applicable)
  - d. ☐ Reference to Microfiche Appendix (if applicable)
  - e. ☒ Background of the Invention
  - f. ☒ Brief Summary of the Invention
  - g. ☒ Brief Description of the Drawings (if drawings filed)
  - h. ☒ Detailed Description
  - i. ☒ Claim(s) as Classified Below
  - j. ☒ Abstract of the Disclosure

# UTILITY PATENT APPLICATION TRANSMITTAL (Large Entity)

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## Application Elements (Continued)

3. ☒ Drawing(s) (when necessary as prescribed by 35 USC 113)
- a. ☒ Formal                      Number of Sheets 8
- b. ☐ Informal                      Number of Sheets \_\_\_\_\_
4. ☐ Oath or Declaration
- a. ☐ Newly executed (original or copy)      ☐ Unexecuted
- b. ☐ Copy from a prior application (37 CFR 1.63(d)) (for continuation/divisional application only)
- c. ☐ With Power of Attorney      ☐ Without Power of Attorney
- d. ☐ DELETION OF INVENTOR(S)  
Signed statement attached deleting inventor(s) named in the prior application,  
see 37 C.F.R. 1.63(d)(2) and 1.33(b).
5. ☐ Incorporation By Reference (usable if Box 4b is checked)  
The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied  
under Box 4b, is considered as being part of the disclosure of the accompanying application and is hereby  
incorporated by reference therein.
6. ☐ Computer Program in Microfiche (Appendix)
7. ☐ Nucleotide and/or Amino Acid Sequence Submission (if applicable, all must be included)
- a. ☐ Paper Copy
- b. ☐ Computer Readable Copy (identical to computer copy)
- c. ☐ Statement Verifying Identical Paper and Computer Readable Copy

## Accompanying Application Parts

8. ☐ Assignment Papers (cover sheet & document(s))
9. ☐ 37 CFR 3.73(B) Statement (when there is an assignee)
10. ☐ English Translation Document (if applicable)
11. ☐ Information Disclosure Statement/PTO-1449      ☐ Copies of IDS Citations
12. ☐ Preliminary Amendment
13. ☒ Acknowledgment postcard
14. ☒ Certificate of Mailing
- ☐ First Class      ☒ Express Mail (Specify Label No.): EL308568250US

# UTILITY PATENT APPLICATION TRANSMITTAL (Large Entity)

(Only for new nonprovisional applications under 37 CFR 1.53(b))

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## Accompanying Application Parts (Continued)

15. ☐ Certified Copy of Priority Document(s) (if foreign priority is claimed)

16. ☒ Additional Enclosures (please identify below):

Claim of Priority without certified copy of Japanese Application

## Fee Calculation and Transmittal

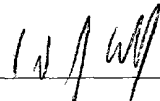
### CLAIMS AS FILED

For	#Filed	#Allowed	#Extra	Rate	Fee
Total Claims	18	- 20 =	0	x \$18.00	\$0.00
Dep. Claims	3	- 3 =	0	x \$78.00	\$0.00
Multiple Dependent Claims (check if applicable) <input type="checkbox"/>					\$0.00
BASIC FEE					\$690.00
OTHER FEE (specify purpose)					\$0.00
TOTAL FILING FEE					\$690.00

☒ A check in the amount of \$690.00 to cover the filing fee is enclosed.

☒ The Commissioner is hereby authorized to charge and credit Deposit Account No. 19-1013/SSMP as described below. A duplicate copy of this sheet is enclosed.

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- ☐ Charge the issue fee set in 37 C.F.R. 1.18 at the mailing of the Notice of Allowance, pursuant to 37 C.F.R. 1.311(b).



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**CERTIFICATE OF MAILING "EXPRESS MAIL" (37 CFR 1.10)**Applicant(s): **Yutaka Yokoyama, et al.**

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Invention: **VIDEO CODING BY ADAPTIVELY CONTROLLING THE INTERVAL BETWEEN SUCCESSIVE PREDICTIVE-CODED FRAMES ACCORDING TO MAGNITUDE OF MOTION**

JCS25 U.S. PTO  
09/574411

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I hereby certify that this **New Patent Application***(Identify type of correspondence)*

is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under

37 CFR 1.10 in an envelope addressed to: The Assistant Commissioner for Patents, Washington, D.C. 20231

on **May 18, 2000***(Date)***Mishelle Spina***(Typed or Printed Name of Person Mailing Correspondence)*  
*(Signature of Person Mailing Correspondence)***EL308568250US***("Express Mail" Mailing Label Number)***Note: Each paper must have its own certificate of mailing.**

1                    TITLE OF THE INVENTION

2            "VIDEO CODING BY ADAPTIVELY CONTROLLING THE  
3            INTERVAL BETWEEN SUCCESSIVE PREDICTIVE-CODED  
4            FRAMES ACCORDING TO MAGNITUDE OF MOTION"

5                    BACKGROUND OF THE INVENTION

6                    Field of the Invention

7            The present invention relates to a video coding apparatus and  
8            method for encoding moving pictures in a compressed format according  
9            to an international standard such as ISO/IEC 13818-2, known as  
10           MPEG-2.

11                   Description of the Related Art

12           The MPEG-2 standard defines three picture types: intra-coded  
13           pictures (I-pictures), predictive coded pictures (P-pictures) and bi-  
14           directionally predicted pictures (B-pictures). I-pictures are coded in  
15           such a way that they can be decoded without knowing anything about  
16           other pictures in a video sequence. The first picture in a group of  
17           pictures is always an I-picture and provides key information for pictures  
18           that follow. P-pictures are coded (i.e., forward predictive coded) by  
19           using information from a reference picture displayed earlier, which may  
20           be either an I-picture or a P-picture. B-pictures also use information  
21           from pictures displayed earlier and from pictures coming in the future  
22           (i.e., forward-and-backward predictive coded). These three picture  
23           types cyclically occur in a predetermined pattern. According to the  
24           current practice, I-pictures occur at intervals represented by an integer  
25           N and the interval between an I-picture and a P-picture is represented

1 by an integer  $M$ . Since these integers are of fixed value, the video  
2 sequence is dynamically controlled so that they are maintained constant.

3 As shown in Fig. 1A, when  $M = 1$ , an I-picture is followed by a  
4 sequence of P-pictures. Each P-picture is coded by using information  
5 from a picture that immediately precedes it. For  $M = 2$  (Fig. 1B), the  
6 interval between an I-picture and a P-picture is equal to "2" and a B-  
7 picture comes in between. In this case, each P-picture is coded by using  
8 information from a picture preceding it by two-picture interval and  
9 each B-picture is coded using information from two pictures, one  
10 immediately preceding it and the other immediately succeeding it. For  
11  $M = 3$  (Fig. 1C), the interval between an I-picture and a P-picture is  
12 equal to "3" and two B-pictures are used to fill in the interval. In this  
13 case, each P-picture is coded by using information from a picture  
14 preceding it by three-picture interval, and one of the two B-pictures is  
15 coded using information from an immediately preceding picture and  
16 from a future picture that comes two-picture intervals following it, and  
17 the other of the two B-pictures is coded using information from a  
18 previous picture that precedes it by two-picture intervals and from a  
19 picture immediately following it. Thus, for  $M \geq 2$ , the number of B-  
20 pictures that come in between non-B-pictures is equal to  $M - 1$ .

21 One reason for using the B-picture is to reduce the amount of  
22 redundant video information inherently contained in the original frame.  
23 For a given quantization scale, the use of B-pictures can reduce the  
24 number of codes with which original pictures are encoded. Hence, the  
25 picture quality can be improved for a given compression (coding) rate.



One prior art approach involves setting a maximum value of per-frame motions and then determining a range of motion vectors to be searched for that is M times the maximum value. However, a significant amount of hardware is necessary to implement this approach. Although the hardware problem can be avoided by the use of an algorithm that simplifies motion vector search, this would be only achieved at the cost of search precision and a poor picture quality would

1 result.

2 Another prior art approach is disclosed in Japanese Laid-Open  
3 Patent Application 9-294266. According to this technique, a  
4 distribution of motion vectors and a differential value of inter-frame  
5 predictions are detected. The M-value is increased according to the  
6 detected distribution and is decreased according to the detected  
7 differential value. Therefore, if a motion-vector search is being  
8 performed on a current P-picture using  $M = 2$  over a given range and  
9 most of the motion vectors are found to exist in that given range, then the  
10 M-value is incremented to 3 and a picture that is three frame intervals  
11 future from the current P-picture is determined as the next P-picture.  
12 Otherwise, the M value remains unchanged and a picture that is two  
13 frame intervals future from the current P-picture is determined as the  
14 next P-picture. If the detected differential value of inter-frame  
15 predictions exceeds some threshold, the M-value is decremented to 1 and  
16 a picture that is one frame interval future from the current P-picture is  
17 determined as the next P-picture. However, it is established that, in  
18 most cases, the distribution of motion vectors is isotropic about an  
19 average vector and its spread (variance) varies depending on the  
20 strength of auto-correlation of motions. Therefore, statistical data of  
21 motion vectors cannot be estimated by the number of motion vectors  
22 which exist in a search range and exceed a threshold value. If motion  
23 vectors have a large mean value in the neighborhood of a threshold  
24 within a given range that is considered sufficient for a search regardless  
25 of their variance, the narrowing of the search range would cause a





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1 memory for storing reference frames, motion vector detection circuitry  
2 for detecting motion vectors in frames from said first memory relative to  
3 reference frames selectively supplied from said second memory  
4 according to a control signal, coding/decoding circuitry for providing  
5 motion-compensated inter-frame prediction and coding on a frame  
6 supplied from said first memory according to the detected motion  
7 vectors and said control signal so that the frame is coded into an intra-  
8 frame coded picture, a predictive coded picture or a bi-directionally  
9 predictive coded picture and locally decoding the coded frame and  
10 storing the decoded frame in said second memory as one of said  
11 reference frames, and mean value calculation circuitry for calculating,  
12 at frame intervals, a mean value of the detected motion vectors.  
13 Decision circuitry determines an interval between successive frames of  
14 said predictive coded picture according to the mean value, and  
15 modifies the control signal according to the determined interval.

16 According to a further aspect, the present invention provides a  
17 video coding method comprising the steps of providing motion-  
18 compensated inter-frame prediction and coding on input frames by  
19 using reference frames so that the input frames are coded into an intra-  
20 frame coded picture, a predictive coded picture or a bi-directionally  
21 predictive coded picture, decoding the coded frames to produce the  
22 reference frames, determining the magnitude of motion of the input  
23 frames relative to the reference frames, determining the interval between  
24 successive frames of the predictive coded picture according to the  
25 determined magnitude of motion and reordering the input frames

1 according to the determined interval.

2 BRIEF DESCRIPTION OF THE DRAWINGS

3 The present invention will be described in further detail with  
4 reference to the accompanying drawings, in which:

5 Figs. 1A, 1B and 1C are illustrations of sequences of frames for  
6 different M-values according to the MPEG-2 standard;

7 Fig. 2 is a block diagram of a video coding apparatus according  
8 to one embodiment of the present invention;

9 Fig. 3 is a flowchart of the operation of the GOP structure  
10 decision circuit according to one embodiment of the present invention;

11 Figs. 4A and 4B are diagrams for illustrating the relationships  
12 between input (display) order and coding order;

13 Fig. 5 is a schematic illustration of the search ranges of the video  
14 coding apparatus;

15 Fig. 6 is a block diagram of a practical form of the video coding  
16 apparatus of the present invention;

17 Fig. 7 is a flowchart of the operation of the GOP structure  
18 decision circuit according to a modified embodiment of the present  
19 invention; and

20 Fig. 8 is a graphic representation of average motion vector, rate of  
21 change of average motion vector and an M-value plotted versus frames.

22 DETAILED DESCRIPTION

23 Referring to Fig. 2, there is shown a video coding apparatus  
24 according to the present invention. The coding apparatus is comprised  
25 of an input frame memory 101 for receiving a plurality of video frames

1 supplied from an input terminal 150 for storage and outputting frames  
2 in a coding order in which these output frames will be encoded. Each  
3 of the stored frames is divided into a plurality of regions or  
4 "macroblocks" and a coding process will be performed on each of the  
5 macroblocks. The reordering of the frames in the input frame memory  
6 101 is controlled by a GOP structure decision circuit 110 which  
7 produces an M-value representing a GOP (group of pictures) structure.  
8 A differential signal representing the error between a predicted frame  
9 provided by an motion-compensated inter-frame predictor 104 and a  
10 frame supplied from memory 101 is produced by a subtractor 105. This  
11 prediction error is coded by an encoder 106 and supplied to an output  
12 terminal 151.

13 The output of encoder 106 is further connected to a decoder 107 to  
14 reconstruct the prediction error, which is combined in an adder 108  
15 with the frame predicted by motion-compensated inter-frame predictor  
16 to produce locally decoded frames. The locally decoded frames are  
17 stored in a reference frame memory 102 as reference frames, which are  
18 then selected and delivered to the motion-compensated inter-frame  
19 predictor 104 and a motion vector searcher 103. The selection of the  
20 reference frames is determined by the GOP structure decision circuit  
21 110.

22 Motion vector searcher 103 receives input frames from the input  
23 frame memory 101 and reference frames from the reference frame  
24 memory 102 and makes a search through a range of input frames  
25 determined by the GOP structure decision circuit 110 for detecting

1 motion vectors. If the video signal is interlaced, the motion vector  
2 searcher 103 may be configured to make a search through each field of  
3 input frames. Alternatively, each field of the frame may be divided into  
4 a plurality of blocks of 16 pixels by 8 lines each. In this case, the motion  
5 vector search may be provided for each of these blocks.

6           Motion-compensated inter-frame predictor 104 uses a reference  
7 frame from the memory 102 to provide a motion-compensated inter-  
8 frame prediction on an input frame from the memory 101 in accordance  
9 with the output of the GOP structure decision circuit 110 and the  
10 output of the motion vector searcher 103, so that the input frame is  
11 coded by the encoder 106 as an I-picture, a P-picture or a B-picture  
12 depending on the M-value determined by the decision circuit 110.  
13 When intra-frame coding is performed, the motion-compensated inter-  
14 frame predictor 104 produces no output signal. In this case, a frame or a  
15 macroblock from the input frame memory 101 is passed through the  
16 subtractor 105 without alterations and supplied to the encoder 106.

17 A mean value calculator 109 is connected to the motion vector  
18 searcher 103 to calculate a mean value of motion vectors detected by the  
19 searcher 103 from each macroblock and produces an average motion  
20 vector for each macroblock. Since the motion vectors detected by the  
21 searcher 103 are vectors in the forward direction (from previous to  
22 current) as well as the backward (from future to current) direction, a  
23 weighted mean value is calculated using one motion vector in a  
24 macroblock.

25 In an alternative embodiment, the motion vector searcher 103

1 makes a decision as to whether or not intra-frame coding is appropriate  
2 during a search through macroblocks of the input frame. If this is the  
3 case, the motion vector searcher 103 provides no output to the mean  
4 value calculator 109.

5 The GOP structure decision circuit 110 is configured to produce  
6 a signal indicating whether the frame currently being encoded is an I-  
7 picture, a P-picture or a B-picture and supplies picture type indication  
8 to the motion vector searcher 103. The GOP structure decision circuit  
9 110 proceeds to perform an M-value updating process according to the  
10 flowchart of Fig. 3.

11 The routine begins with initialization of the M-value at step 200.  
12 At decision step 201, the decision circuit 110 determines from the  
13 current M-value whether or not the current frame is a predictive coded  
14 picture (P-picture). If the decision is affirmative at step 201, the routine  
15 proceeds to step 202 to receive a weighted mean value from the mean  
16 value calculator 109 and determines, at step 203, whether or not the  
17 current frame is a still picture. If the current frame is a still picture, the  
18 routine proceeds to decision step 204 to determine if the current M-value  
19 is smaller than a predefined maximum value. If the current M-value is  
20 smaller than the maximum value, the decision circuit 110 increments M  
21 by a prescribed amount (step 205).

22 If the current frame is not a still picture, the routine proceeds  
23 from step 203 to decision step 206 to check to see if the current P-picture  
24 is a fast moving picture. If the current frame is a fast moving picture,  
25 the decision circuit 110 determines, at step 207, whether the current M-

1 value is greater than 1. If M is greater than 1, the M-value is  
2 decremented by a prescribed value (step 208).

3 Following the execution of step 205 or 208, the decision circuit  
4 110 proceeds to step 209 to control the frame memories 101, 102, the  
5 motion vector searcher 103 and the motion-compensated inter-frame  
6 predictor 104 according to the updated M-value, and then returns to  
7 step 201 to repeat the M-value updating process. At decision step 201 of  
8 each successive updating process, the decision circuit 110 determines the  
9 picture type from the M-value updated in a previous process.

10 If each of the decisions made at steps 201, 204, 206 and 207 is  
11 negative, the decision circuit 110 proceeds to step 209 to control the  
12 memories 101, 102, searcher 103 and predictor 104 according to the  
13 current M-value.

14 The starting value with which the M-value is initialized may be a  
15 maximum value. At steps 205 and 208, the M-value may be varied with  
16 a unit value of one.

17 The updating process of the GOP structure decision circuit 110  
18 will be visualized by the following description with reference to Figs.  
19 4A and 4B by assuming that the input memory 101 has the capacity of  
20 storing as many frames as necessary to provide reordering when the M-  
21 value is maximum.

22 In Fig. 4A, the M-value is successively decremented if the GOP  
23 structure decision circuit 110 determines that a current frame is a fast  
24 moving picture. If the initial M-value is 3, input frames are stored in  
25 the input frame memory 101 in the order 1(B), 2(B), 3(I), 4(B), 5(B) and

1 6(P) for a period necessary for reordering. These stored frames are  
2 reordered such that the third frame 3(I) comes first in the coding order  
3 so that it can be intra-frame coded as an I-picture I3. The I-picture I3 is  
4 followed by the first and second frames 1(B) and 2(B) so that they are  
5 coded as B-pictures B1 and B2. The sixth frame 6(P) comes in the  
6 fourth position so that it can be coded as a P-picture P6. The P-picture  
7 P6 is followed by the fourth and fifth frames 4(B) and 5(B), which will  
8 be coded as B-pictures B4 and B5. When the M-value is decremented to  
9 "2", subsequent input frames are stored in the frame memory 101 in the  
10 order 7(B), 8(P), 9(B) and 10(P) for a period necessary for reordering.  
11 Since the frame 8(P) must precede the frame 7(B), these frames are  
12 reordered and coded as a P-picture P8 and a B-picture B7. Likewise,  
13 since the frame 10(P) must precede the frame 9(B), these frames are  
14 reordered and coded as a P-picture P10 and a B-picture B9. When the  
15 M-value is further decremented to "1", subsequent frames are stored in  
16 the frame memory 101 in the order 11(P), 12(P) and 13(P). In the  
17 illustrated example, since the output frames are delayed by two frames  
18 with respect to the input frames, input frames 11(P), 12(P) and 13(P) are  
19 stored for a two-frame interval and delivered without being reordered  
20 and encoded into P-pictures P11, P12 and P13.

21 In Fig. 4B, the M-value is successively incremented if the GOP  
22 structure decision circuit 110 determines that a current frame is a still  
23 picture, starting from  $M = 1$  in which input frames are stored in the  
24 frame memory 101 in the order 14(P), 15(P) and 16(P) for a two-frame  
25 interval and delivered without being reordered and encoded as frames

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1 P14, P15 and P16. When the M-value is incremented to "2", frames  
2 17(B) and 18(P) are reversed in order, and frames 19(B) and 20(P) are  
3 reversed in order and delivered as P18, B17, P20 and B19. When the M-  
4 value is incremented to "3", frame 23(P) comes earlier than frames 21(B)  
5 and 22(B), and frame 26(P) comes earlier than frames 24(B) and 25(B).  
6 All of these frames are delivered as P23, B21, B22, P26, B24 and B25.

7 Fig. 5 schematically illustrates search ranges of the motion vector  
8 searcher 103 for different M-values in a one-dimensional scale (note that  
9 the actual search ranges are two-dimensional). Assume that the motion  
10 vector searcher 103 is making a search in a given direction in the range  
11 between  $R_1$  and  $R_2$ . Consider the relationships between a current frame  
12 and reference frames (P-pictures) with  $M = 1, 2$  and  $3$ . As shown in Fig.  
13 5, when the searcher 103 is making a search with  $M = 1$ , the increment  
14 of frame interval by one frame will enlarge the search range by a factor  
15 of 2 and the increment of frame interval by two frames will enlarge the  
16 range by a factor of 3. Likewise, when the searcher 103 is making a  
17 search with  $M = 2$ , the increment of frame interval by one frame will  
18 enlarge the search range by a factor of  $3/2$ . In this way, when there is a  
19 fast moving object the searcher 103 can keep track of its motion vectors.

20 When fast moving objects are detected and hence it is difficult to  
21 perform a wide-range vector search, the GOP structure decision circuit  
22 110 decrements the M-value to shorten the frame interval between P-  
23 pictures so that the performance of the motion-compensated inter-frame  
24 predictor 104 is increased. In contrast, when still pictures are detected  
25 and hence it is not necessary to perform a wide-range vector search, the

1 GOP structure decision circuit 110 increments the M-value to lengthen  
2 the frame interval between P-pictures to increase intervening B-pictures  
3 so that the overall coding efficiency of the apparatus is improved.

4 Fig. 6 shows a practical form of the video coding apparatus of the  
5 present invention in which parts corresponding in significance to those  
6 of Fig. 2 are marked with the same numerals and the description thereof  
7 is omitted for simplicity. The encoder of Fig. 2 is replaced with a DCT  
8 (discrete cosine transform) coder 600 and a quantizer 601 and the  
9 decoder is replaced with a dequantizer 602 and an inverse DCT circuit  
10 603. DCT coefficient data is quantized by the quantizer 601 and  
11 supplied to a variable length coder 605 as well as to the dequantizer 602.  
12 Variable length coder 605 performs run-length coding on the quantized  
13 DCT coefficient by using the motion vector supplied from the motion  
14 vector searcher 103.

15 The flowchart shown in Fig. 7 is used to operate the GOP  
16 structure decision circuit of Fig. 6. The M-value is first initialised at  
17 step 700 and the picture type is determined at step 701 from the M-  
18 value. If a P-picture is detected, the GOP structure decision circuit 110  
19 proceeds to step 702 to receive a mean value of horizontal motion vectors  
20 (MVavex) and a mean value of vertical motion vectors (MVavey) from  
21 the mean value calculator 109. At step 703, the decision circuit 110  
22 compares the M-value with a reference value "1". If  $M = 1$ , flow  
23 proceeds to step 704 to check to see if the following conditions are  
24 simultaneously met:

25  $|MVavex|$  is smaller than a threshold value Th1; and

1        $|MV_{avey}|$  is smaller than a threshold value Th2.

2   If the above-mentioned conditions are met, the decision circuit 110  
3   proceeds to step 705 to calculate the rate of change of horizontal average  
4   motion vector ( $\Delta MV_{avex}$ ) and the rate of change of vertical average  
5   motion vector ( $\Delta MV_{avey}$ ) as follows.

6       
$$\Delta MV_{avex} = MV_{avex}(t) - MV_{avex}(t - 1)$$

7       
$$\Delta MV_{avey} = MV_{avey}(t) - MV_{avey}(t - 1)$$

8   where  $t$  represents the frame number.

9       GOP structure decision circuit 110 proceeds to step 706 to  
10   determine whether the following conditions are simultaneously satisfied:

11        $|\Delta MV_{avex}|$  is smaller than threshold Th3; and

12        $|\Delta MV_{avey}|$  is smaller than threshold Th4.

13   If these conditions are simultaneously met, flow proceeds to step 707 to  
14   increment the M-value by a predetermined amount.

15       If M is greater than 1, the decision circuit 110 proceeds from step  
16   703 to step 708 to determine if one of the following conditions is met:

17        $|MV_{avex}|$  is equal to or greater than a threshold value Th5; or

18        $|MV_{avey}|$  is equal to or greater than a threshold value Th6.

19   If the decision at step 708 is affirmative, flow proceeds to step 709 to  
20   decrement the M-value by a predetermined amount. At step 710, the  
21   decision circuit 110 controls the frame memories 101, 102, the motion  
22   vector searcher 103 and the motion-compensated inter-frame predictor  
23   104 according to the updated M-value, and then returns to step 701 to  
24   repeat the M-value updating process.

25       If each of the decisions made at steps 701, 704, 706 and 708 is

1 negative, the decision circuit 110 proceeds to step 710 to control the  
2 memories 101, 102, searcher 103 and predictor 104 according to the  
3 current M-value.

4 In order to evaluate the performance of the video coding  
5 apparatus, fast moving pictures were experimentally used as input  
6 frames and the incremental unit of steps 707 and 709 was set equal to 2  
7 so that the M-value is switched between 1 and 3 when each of the  
8 decisions at steps 706 and 708 is affirmative. Results of the experiment  
9 are shown in Fig. 8, in which the horizontal average motion vector, the  
10 rate of change of the horizontal average motion vector and the  
11 corresponding M-value are plotted as a function of the number of  
12 frames. It is seen that when a fast moving picture is detected, the M-  
13 value is reset to 1. Since the time-varying rate of motion vectors is taken  
14 into account by steps 705 and 706, the M-value is maintained at 1 when  
15 the number of frames is 170, where the average motion vector is crossing  
16 the zero level. In this way, the updating performance of the M-value is  
17 optimized.

18 The average motion vectors  $MV_{avex}$  and  $MV_{avey}$  used by the  
19 GOP structure decision circuit 110 could be altered in a number of  
20 ways. By designating such vectors as  $|MV|$ , either one of the following  
21 conversions can be used:

22  $|MV| = |MV_{avex}| + |MV_{avey}|$

23  $|MV| = MV_{avex}^2 + MV_{avey}^2$

24  $|MV| = \text{Square root of } (MV_{avex}^2 + MV_{avey}^2)$

25  $|MV| = a * |MV_{avex}| + b * |MV_{avey}|$

- 1  $|MV| = \text{Square root of } (a * MV_{avex}^2 + b * MV_{avey}^2)$
- 2 where a and b are constants.

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What is claimed is:

- 1           1.    A video coding apparatus comprising:  
2           coding/decoding circuitry for providing motion-compensated  
3   inter-frame prediction coding on input frames by using reference  
4   frames so that the input frames are coded into an intra-frame coded  
5   picture, a predictive coded picture or a bi-directionally predictive  
6   coded picture and decoding said coded frames to produce said  
7   reference frames; and  
8           decision circuitry for determining a magnitude of motion of  
9   said input frames relative to said reference frames, determining an  
10   interval between successive frames of said predictive coded picture  
11   according to the magnitude of motion, and reordering said input  
12   frames according to the determined interval.
- 1           2.    A video coding apparatus as claimed in claim 1, wherein  
2   said decision circuitry is configured to increase said interval when the  
3   determined magnitude of said motion decreases and decreases said  
4   interval when the determined magnitude of said motion increases.
- 1           3.    A video coding apparatus as claimed in claim 1, wherein  
2   said decision circuitry is configured to increment said interval when  
3   said magnitude of motion is smaller than a first threshold and  
4   decrement said interval when said magnitude of motion is greater  
5   than a second threshold.

1        4.    A video coding apparatus comprising:  
2        a first memory for storing a plurality of input frames;  
3        a second memory for storing reference frames;  
4        motion vector detection circuitry for detecting motion vectors  
5        in frames from said first memory relative to reference frames  
6        selectively supplied from said second memory according to a control  
7        signal;  
8        coding/decoding circuitry for providing motion-compensated  
9        inter-frame prediction and coding on a frame supplied from said first  
10       memory according to the detected motion vectors and said control  
11       signal so that the frame is coded into an intra-frame coded picture, a  
12       predictive coded picture or a bi-directionally predictive coded  
13       picture and locally decoding the coded frame and storing the  
14       decoded frame in said second memory as one of said reference frames;  
15       mean value calculation circuitry for calculating, at frame  
16       intervals, a mean value of the detected motion vectors; and  
17       decision circuitry for determining an interval between  
18       successive frames of said predictive coded picture according to the  
19       mean value, and modifying said control signal according to the  
20       determined interval.

1        5.    A video coding apparatus as claimed in claim 4, wherein  
2        said decision circuitry is configured to increase said interval when  
3        said mean value decreases and decrease said interval when said mean  
4        value increases.

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9. A video coding apparatus as claimed in claim 8, wherein said mean value comprises a horizontal component and a vertical component and wherein said decision circuitry is configured to determine, as said time-varying rate, a difference between successive ones of said mean value of horizontal component and a difference in a vertical direction between successive ones of said mean value of vertical component and increment said interval when said differences are simultaneously smaller than respective thresholds.

1        10. A video coding apparatus as claimed in claim 4, wherein



2 said coding/decoding circuitry comprises:  
3 motion-compensated inter-frame prediction circuitry for  
4 performing motion-compensated inter-frame prediction on an input  
5 frame supplied from said first memory according to the detected  
6 motion vectors and to a control signal applied thereto;  
7 subtraction circuitry for producing a differential frame from a  
8 frame supplied from the first memory and an output signal of said  
9 prediction circuitry;  
10 encoding circuitry for coding said differential frame so that  
11 said input frame is coded into an intra-frame coded picture, a  
12 predictive coded picture or a bi-directionally predictive coded  
13 picture;  
14 decoding circuitry for decoding the coded differential frame;  
15 and  
16 summing circuitry for producing a combined frame from the  
17 decoded differential frame and the output of signal of said prediction  
18 circuitry and storing the combined frame into said second memory.

1 11. A video coding apparatus as claimed in claim 10,  
2 wherein said encoding circuitry comprises a discrete cosine  
3 transform (DCT) coder for transforming said differential frame to  
4 DCT coefficients, a quantizer for quantizing the DCT coefficients,  
5 and a variable length coder for transforming the quantized  
6 coefficients and the motion vector detected by said motion vector  
7 detection circuitry to run-length codes, and wherein said decoding  
8 circuitry comprises a dequantizer for dequantizing the quantized

9 differential frame and a DCT decoder for decoding the  
10 dequantized differential frame.

1 12. A video coding method comprising the steps of:  
2 a) providing motion-compensated inter-frame prediction  
3 and coding on input frames by using a reference frame so that the  
4 input frames are coded into an intra-frame coded picture, a  
5 predictive coded picture or a bi-directionally predictive coded  
6 picture;  
7 b) locally decoding said coded frames to produce said  
8 reference frames;  
9 c) determining a magnitude of motion of said input frames  
10 relative to said reference frames;  
11 d) determining an interval between successive frames of said  
12 predictive coded picture according to the determined magnitude of  
13 motion; and  
14 e) reordering said input frames according to the determined  
15 interval.

1 13. A video coding method as claimed in claim 12, wherein  
2 the step (c) comprises the steps of detecting motion vectors in said  
3 input frames relative to said reference frames and calculating, at  
4 frame intervals, a mean value of the detected motion vectors to  
5 represent said magnitude of motion.

1 14. A video coding method as claimed in claim 12, wherein

2 the step (d) comprises increasing said interval when the determined  
3 magnitude of motion decreases and decreasing said interval when the  
4 determined magnitude of motion increases.

1 15. A video coding method as claimed in claim 12, wherein  
2 the step (d) comprises the step of incrementing said interval when  
3 said mean value is smaller than a first threshold and decrementing  
4 said interval when said mean value is greater than a second threshold.

1 16. A video coding method as claimed in claim 17, wherein  
2 said mean value comprises a horizontal component and a vertical  
3 component and wherein the step (d) comprises the steps of  
4 incrementing said interval when said horizontal and vertical  
5 components are simultaneously smaller than respective thresholds and  
6 decrementing said interval when one of said horizontal and vertical  
7 components is greater than a threshold.

1 17. A video coding method as claimed in claim 15, wherein  
2 the step (d) further comprises the steps of determining a time-varying  
3 rate of said mean value and incrementing said interval when the  
4 time-varying rate is smaller than a predetermined rate.

1 18. A video coding method as claimed in claim 17, wherein  
2 said mean value comprises a horizontal component and a vertical  
3 component and wherein the step (d) comprises the steps of  
4 determining, as said time-varying rate, a difference between successive  
5 ones of said mean value of horizontal component and a difference in a  
6 vertical direction between successive ones of said mean value of

- 7 vertical component and incrementing said interval when said
- 8 differences are simultaneously smaller than respective thresholds.

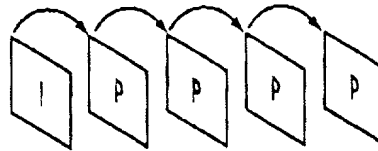
ABSTRACT OF THE DISCLOSURE

1        In a video coding apparatus, coding/decoding circuitry  
2   provides motion-compensated inter-frame prediction coding on input  
3   frames by using reference frames so that the input frames are coded  
4   into an intra-frame coded picture, a predictive coded picture or a bi-  
5   directionally predictive coded picture and decoding the coded  
6   frames to produce reference frames. Decision circuitry determines the  
7   magnitude of motion of the input frames relative to the reference  
8   frames, determines the interval between successive frames of the  
9   predictive coded picture according to the determined magnitude of  
10   motion and reorders the input frames according to the determined  
11   interval.

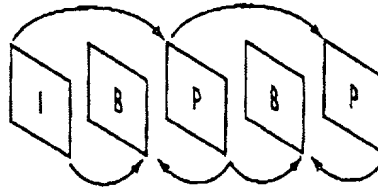
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**FIG. 1A**

M = 1

**FIG. 1B**

M = 2

**FIG. 1C**

M = 3

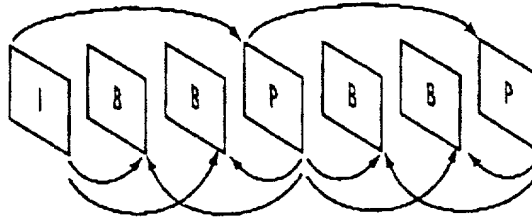
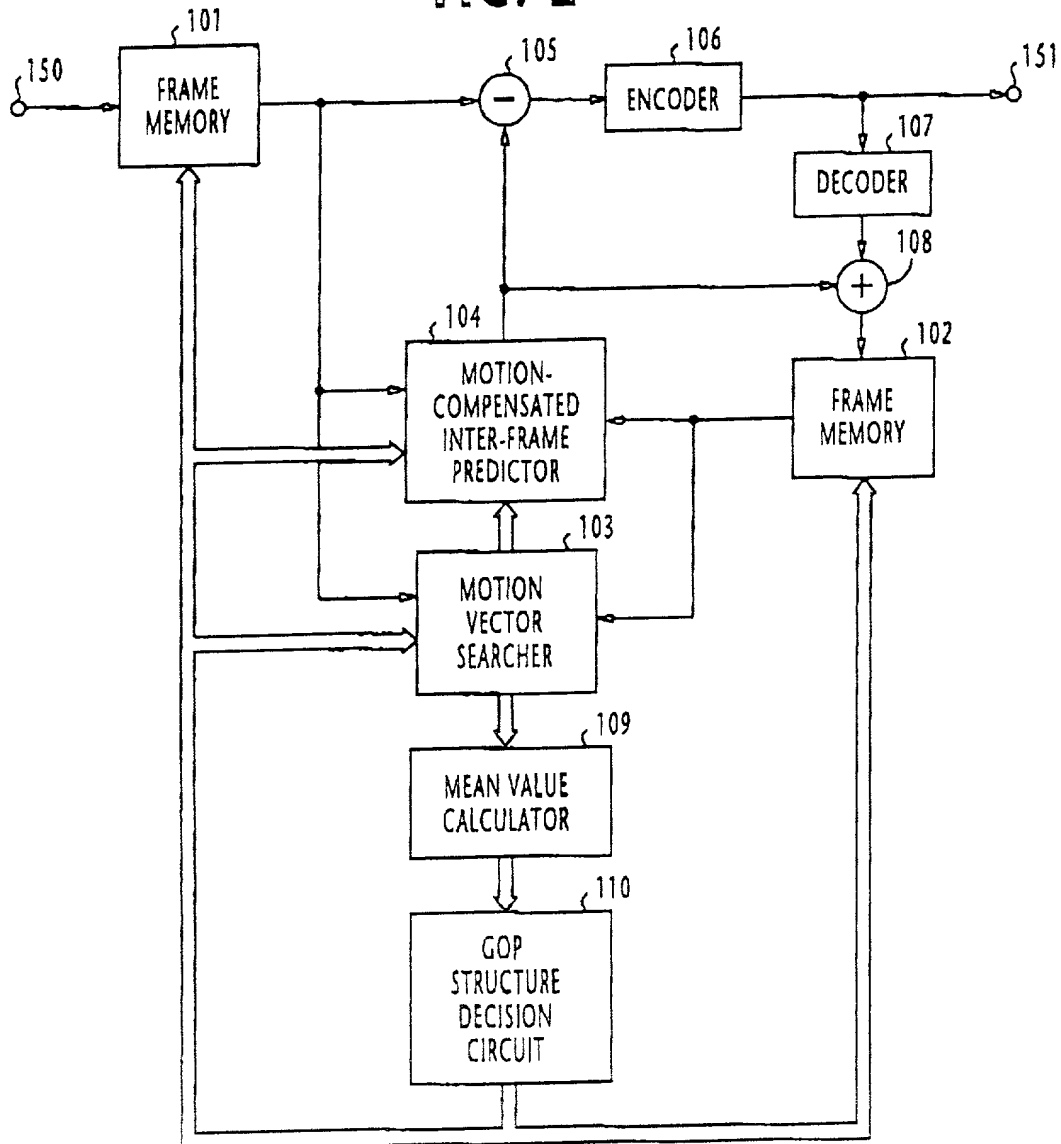
**FIG. 2**

FIG. 3

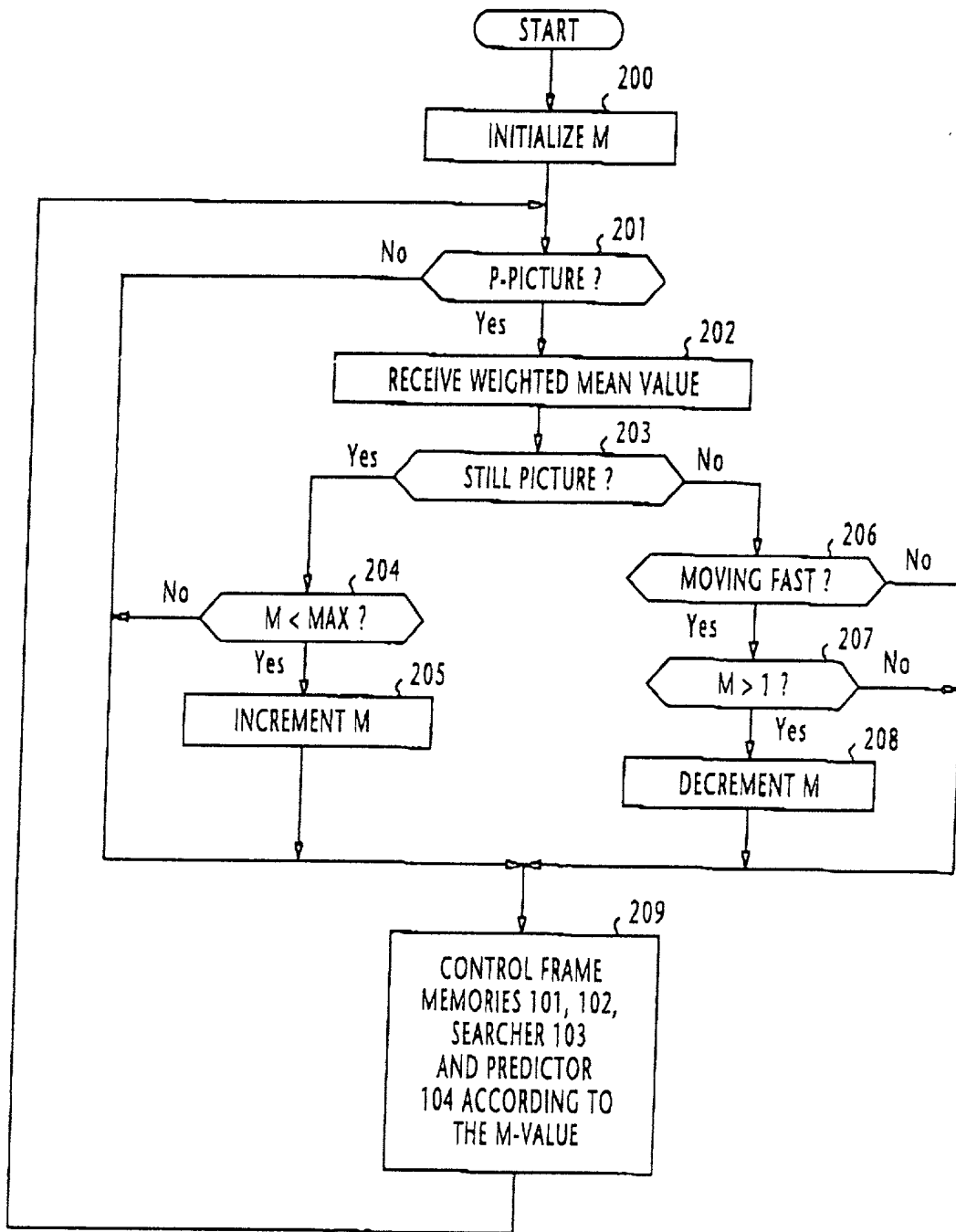


FIG. 4A

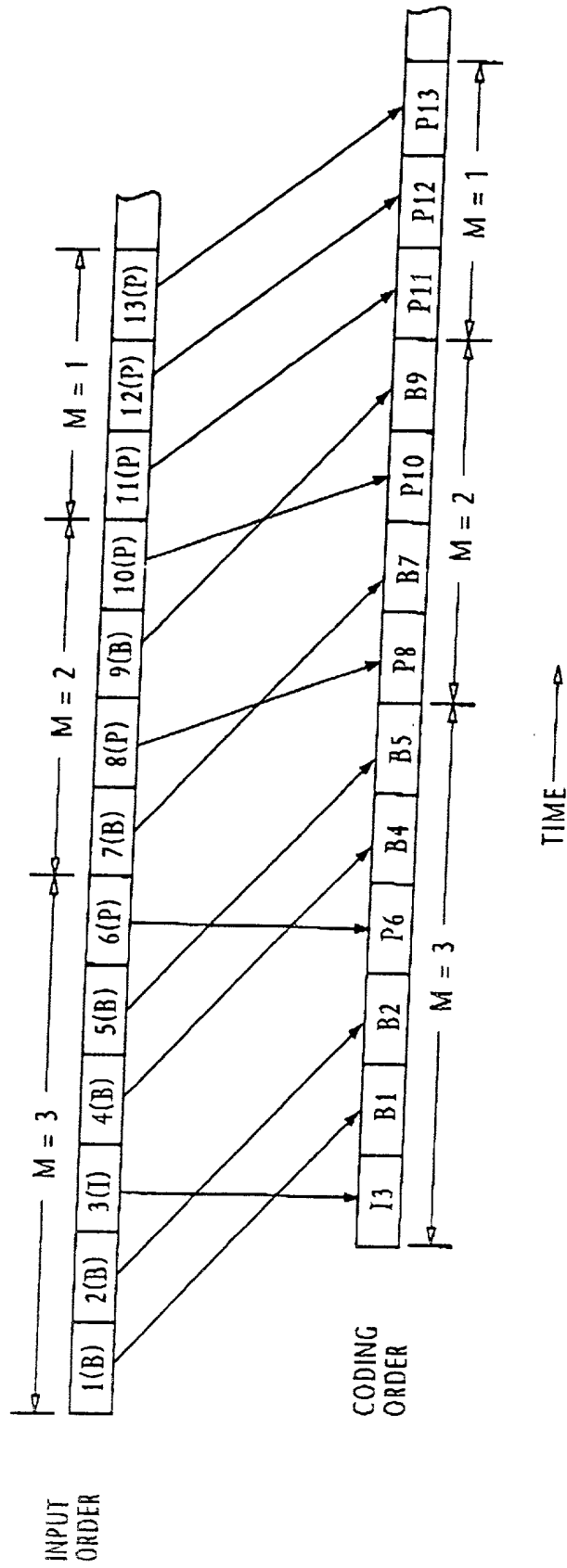
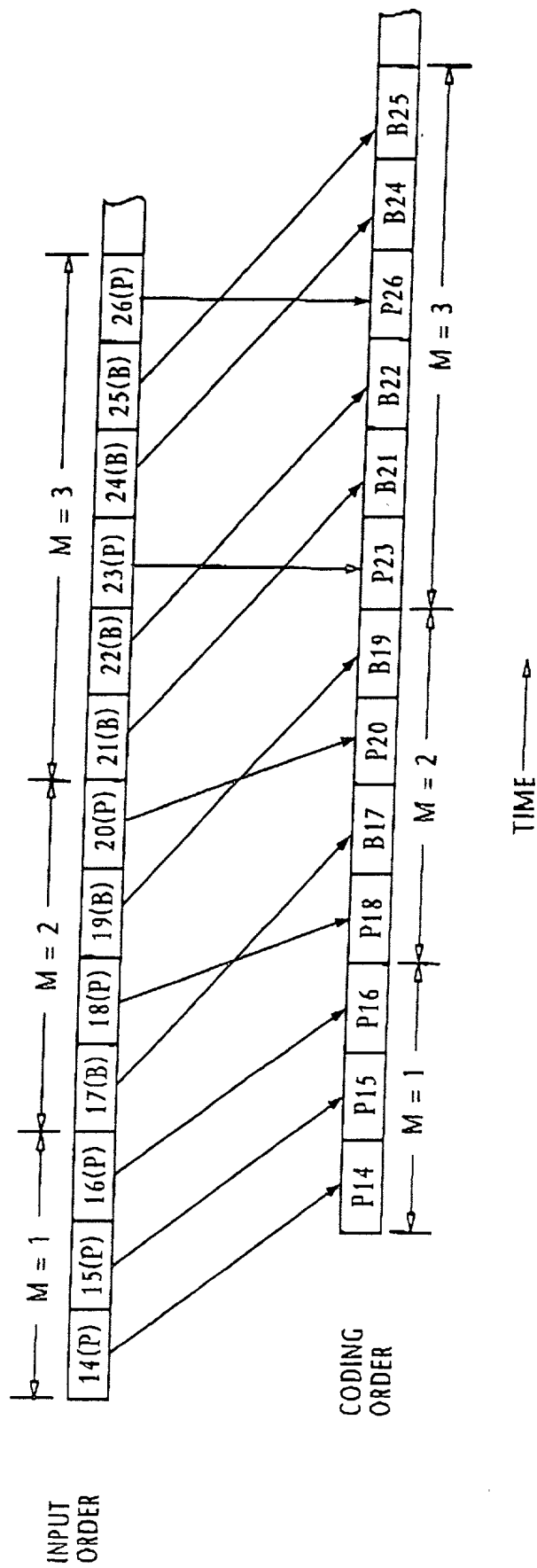




FIG. 4B



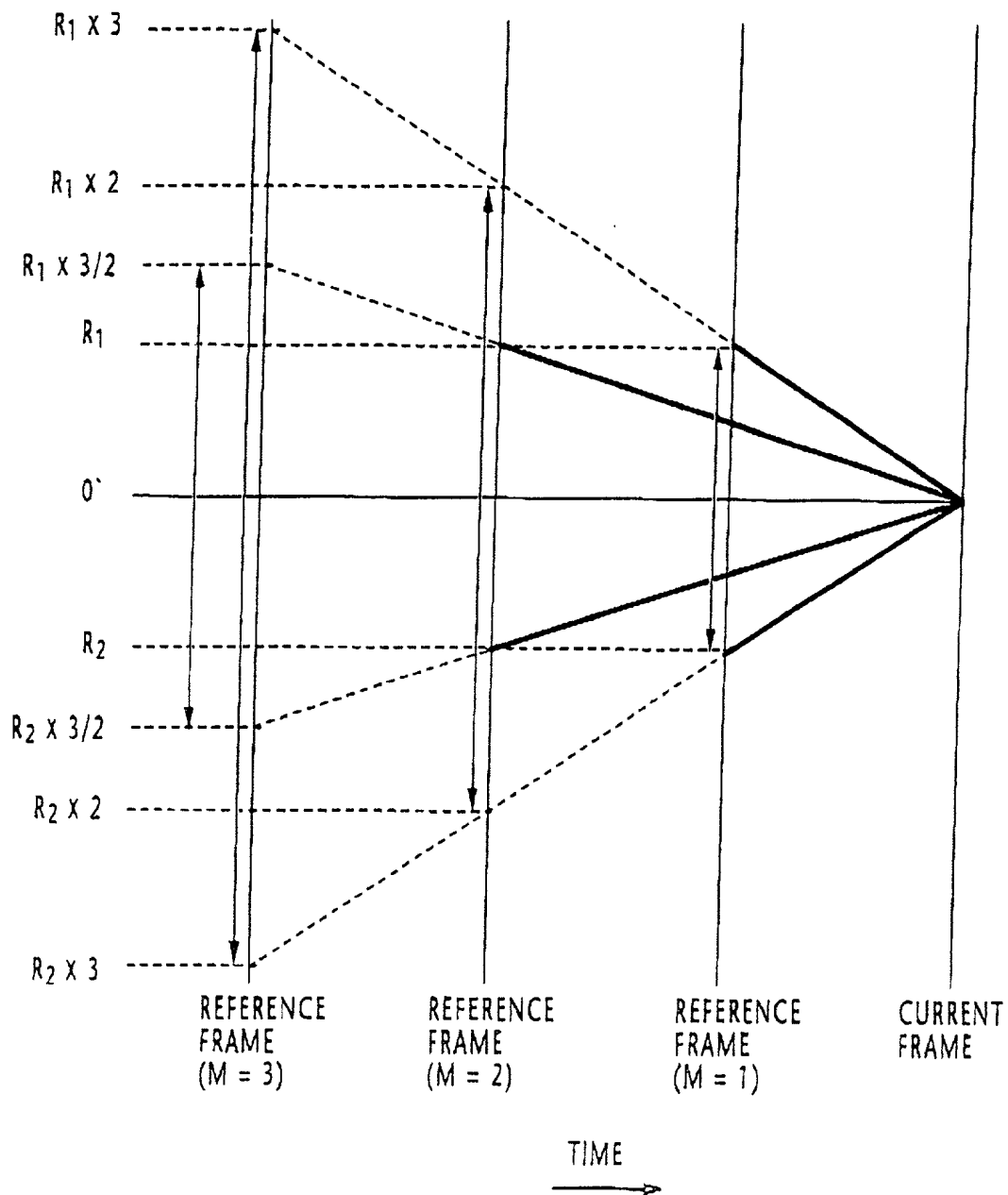
**FIG. 5**

FIG. 6

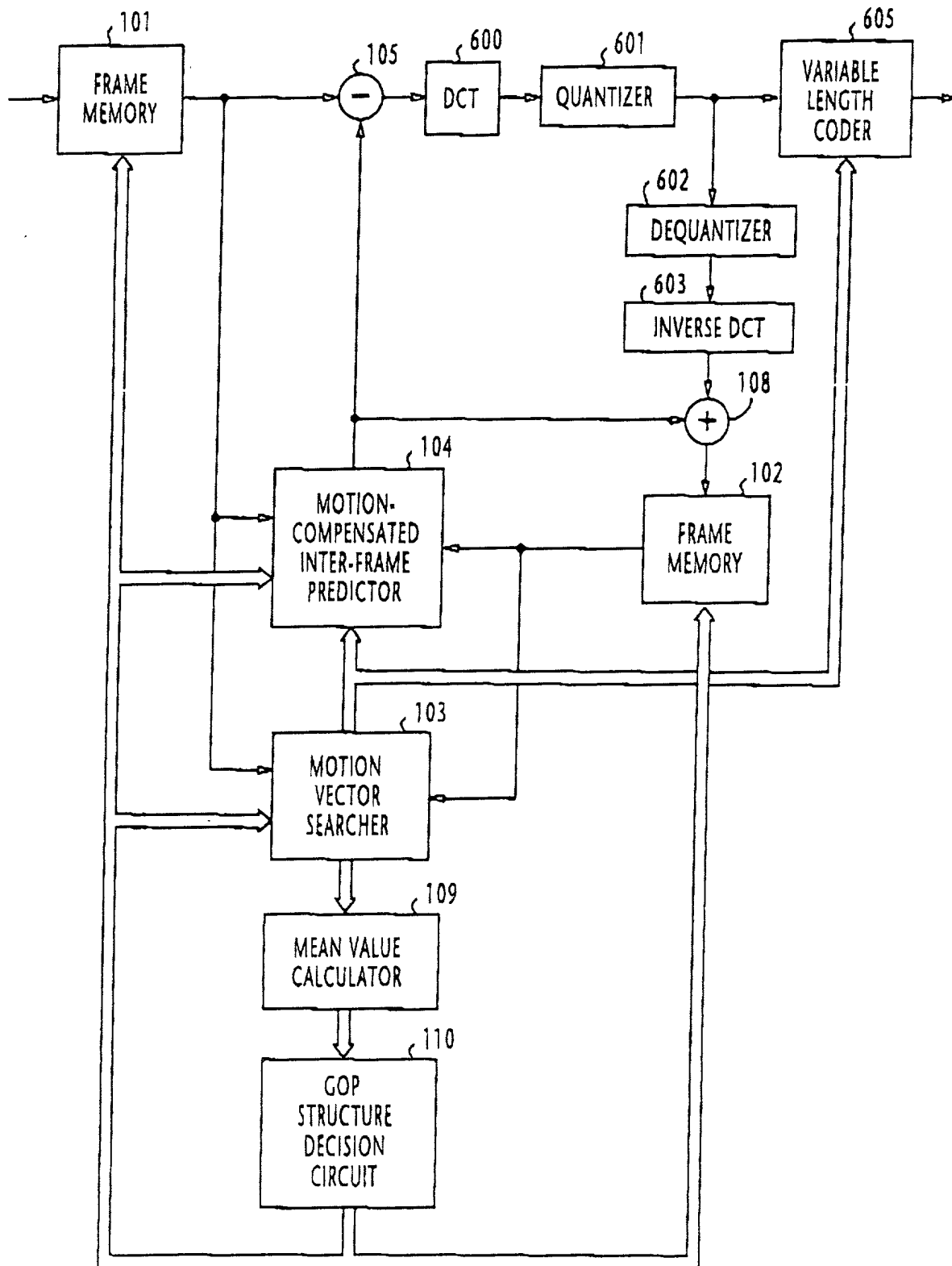


FIG. 7

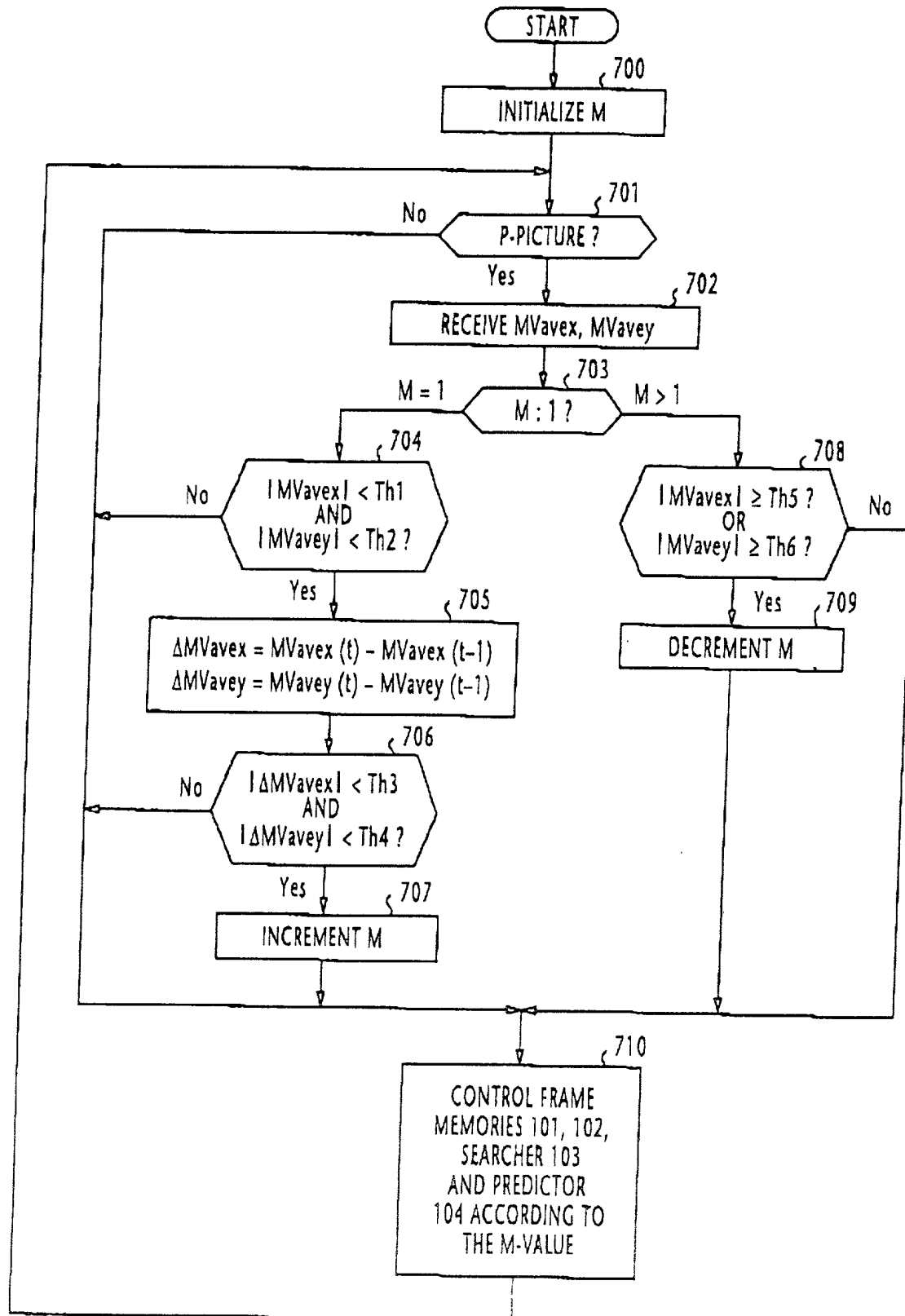


FIG. 8

